

WHAT IS CLAIMED IS:

1. (Cancelled) An autoprotected optical communication ring network, comprising:

a first and a second optical carrier having opposite transmission directions;

5 and

a plurality of optically reconfigurable nodes optically connected along the first and second optical carriers and adapted to communicate in pairs by respective links susceptible to failure, the ring network having a nominal operative condition in which the nodes of each of the pairs are optically configured so as to exchange  
10 optical signals on a respective working arc path at a respective first wavelength ( $\lambda_x$ ) on the first carrier and at a respective second wavelength ( $\lambda_y$ ) different from said first wavelength ( $\lambda_x$ ) on the second carrier, said respective working path having a complementary arc path defining a protection arc path in which the first wavelength ( $\lambda_x$ ) on the first carrier and the second wavelength ( $\lambda_y$ ) on the second carrier can be  
15 used for further links and the first wavelength ( $\lambda_x$ ) on the second carrier and the second wavelength ( $\lambda_y$ ) on the first carrier are reserved for protection such that the ring network has a failure operative condition in which the nodes terminating a failed link are optically reconfigured so as to exchange optical signals on the protection arc path at the respective second wavelength ( $\lambda_y$ ) on the first carrier and at the respective  
20 first wavelength ( $\lambda_x$ ) on the second carrier, wherein the reconfiguration of one or more of the nodes reflects reconfiguration at a channel level associated with the ring network.

2. (Cancelled) The ring network of Claim 1, wherein each of said  
25 plurality of reconfigurable nodes is configured to manage a predetermined subset of wavelengths within a set of transmission wavelengths, and wherein each of the nodes includes a first and a second optical add/drop multiplexer that may be serially connected to said first and second carriers respectively in order to communicate said subset of wavelengths to said first and second carriers.

3. (Cancelled) The ring network of Claim 1, wherein said plurality of reconfigurable nodes includes a signal input, a signal output, and a reconfigurable optical switch unit operable to couple said signal input and said signal output to said first and second carriers respectively.

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4. (Cancelled) The ring network of Claim 3, wherein said signal input is optically coupled to an optical transmitter and said signal output is optically coupled to an optical receiver.

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5. (Cancelled) The ring network of Claim 3, wherein each of said plurality of reconfigurable nodes includes information insertion devices optically coupled to said signal input and adapted to position signaling information into one or more optical signals.

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6. (Cancelled) The ring network of Claim 5, wherein said information insertion devices include optical transponders operable to optically couple said optical switch unit to said first and second carriers.

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7. (Cancelled) The ring network of Claim 3, wherein at least one of said reconfigurable nodes includes a first signal splitter adapted to receive a signal from a selected one of the first and the second carriers and to split said signal into a first and a second fraction to be communicated toward a signal output.

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8. (Cancelled) The ring network of Claim 7, wherein a selected one or more of said reconfigurable nodes includes a second signal splitter optically coupled to a signal input and adapted to split a signal coming from the signal input into a first and a second fraction to be communicated toward the first carrier and second carriers respectively.

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9. (Cancelled) The ring network of Claim 3, wherein said optical switch unit includes a first switch having a first input that is optically coupled to a signal input.

10. (Cancelled) The ring network of Claim 9, wherein said optical switch unit includes a second switch having a first input that is coupled to the first carrier and a second input that is coupled the second carrier, and wherein an output of the second switch is optically coupled to a signal output.

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11) (Cancelled) Optical transmission system, including a first and a second ring network according to claim 3, wherein a first reconfigurable node (D) of the first ring network has a signal input (IN<sub>1</sub>, IN<sub>2</sub>) which is optically coupled to a signal output (OUT<sub>1</sub>, OUT<sub>2</sub>) of a second reconfigurable node (D') of the second ring network.

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12) (Cancelled) Optical transmission system according to claim 11, wherein the second reconfigurable node (D') has a signal input (IN<sub>1</sub>, IN<sub>2</sub>) which is optically coupled to a signal output (OUT<sub>1</sub>, OUT<sub>2</sub>) of the first reconfigurable node (D).

15 13) (Cancelled) Optical transmission system according to claim 11, wherein a third reconfigurable node (E) of the first ring network has a signal input (IN<sub>1</sub>, IN<sub>2</sub>) which is optically coupled to a signal output (OUT<sub>1</sub>, OUT<sub>2</sub>) of a fourth reconfigurable node (E') of the second ring network, and the fourth reconfigurable node (E') has a signal input (IN<sub>1</sub>, IN<sub>2</sub>) which is optically coupled to a signal output  
20 (OUT<sub>1</sub>, OUT<sub>2</sub>) of the third reconfigurable node (E).

14. (Cancelled) A method to autoprotect an optical ring network, said ring network including a first and a second optical carrier having opposite transmission directions and a plurality of nodes optically connected along the first and the second optical carriers and adapted to communicate in pairs in order to define  
5 bidirectional links, each of the pairs including a first and a second link termination node adapted to mutually communicate at respective first and second wavelengths, the method comprising:

exchanging signals between the first and the second link termination nodes on a working arc path of said ring network by using the first wavelength on the first  
10 carrier and the second wavelength on the second carrier, said working path having a complementary arc path defining a protection arc path in which the first wavelength on the first carrier and the second wavelength on the second carrier can be used for further links, wherein the first wavelength on the second carrier and the second wavelength on the first carrier are reserved for protection;

15 checking if a failure is present in the ring network producing a failed link; and  
optically reconfiguring, in the presence of the failure, the link terminating nodes of said failed link so that signals may be exchanged on the protection arc path by using the first wavelength on the second carrier and the first wavelength on the second carrier, wherein the reconfiguration of one or more of the nodes reflects  
20 reconfiguration at a channel level associated with the ring network.

15. (Cancelled) The method of Claim 14, wherein each node of said plurality of nodes is adapted to manage a predetermined subset of wavelengths within a set of transmission wavelengths carried by the first and the second carriers,  
25 said step of exchanging including optically separating, at each node of said plurality of nodes, each wavelength of the subset of wavelengths from a set of transmission wavelengths.

16. (Cancelled) The method of Claim 14, further comprising:  
inserting a signal into one of said nodes;  
splitting said signal into a first and a second fraction; and  
sending said first fraction toward the first carrier and the second fraction  
5 toward the second carrier.

17. (Cancelled) The method of Claim 14, further comprising:  
receiving a signal in one of said nodes from either the first or the second  
carrier;  
10 splitting said signal into a first and a second fraction; and  
sending the first fraction toward the same carrier and the second fraction  
towards a signal output of said node.

18) (Cancelled) Method according to claim 14, wherein the step of checking  
15 includes verifying, in each node of said plurality of nodes and for each wavelength of  
the respective set of wavelengths, if signals are received.

19) (Cancelled) Method according to claim 14, wherein said step of checking  
includes verifying, in each node of said plurality of nodes and for each wavelength of  
20 the respective set of wavelengths, if signals are received degraded.

20) (Cancelled) Method according to claim 14, wherein said step of checking  
includes verifying, in each node of said plurality of nodes and for each wavelength of  
the respective set of wavelengths, if signals include a failure message.  
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21. (Cancelled) The method of Claim 14, further comprising:  
transmitting a failure message from the first link termination node to the  
second link termination node if a signal transmitted from the second link termination  
node to the first link termination node is not received or is degraded.

22. (Cancelled) The method of Claim 14, wherein said step of optically reconfiguring includes switching optical connections that selectively couple an optical transmitter and an optical receiver to said first and second carriers respectively.

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23. (Cancelled) The method of Claim 14, wherein the step of exchanging signals includes the following steps executed in the first link termination node:

generating an optical signal carrying information;

converting the optical signal into an electrical signal;

10 adding information to the electrical signal;

reconverting the electrical signal into an optical signal provided with a predetermined wavelength adapted for transmission; and

communicating the optical signal at the predetermined wavelength to a selected one of the first and the second carriers.

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24. (Cancelled) The method of Claim 14, wherein the step of exchanging signals includes the following steps executed in the second link termination node:

receiving the optical signal at the predetermined wavelength from a selected one of the first and the second carriers;

20 converting the optical signal at the predetermined wavelength into an electrical signal;

extracting information from the electrical signal;

reconverting the electrical signal into an optical signal with a wavelength adapted for reception; and

25 receiving the optical signal with the wavelength adapted for reception.

25) (Cancelled) Reconfigurable node for an autoprotected optical communication ring network, comprising a receiving/transmitting module (6) including:

- a signal input ( $IN_1$ ) for the insertion into the node of a signal including information to be transmitted in the network;
- 5     - a signal output ( $OUT_1$ ) for the extraction from the node of a signal including information transmitted in the network;
- a first transmitting transponder ( $TxT_1(\lambda_x)$ ) for optically coupling to a first carrier (2) of the network and adapted to modulate a signal at a first wavelength ( $\lambda_x$ );
- 10    - a second transmitting transponder ( $TxT_1(\lambda_y)$ ) for optically coupling to the first carrier (2) and adapted to modulate a signal at a second wavelength ( $\lambda_y$ );
- a third transmitting transponder ( $TxT_2(\lambda_x)$ ) for optically coupling to a second carrier (3) of the network and adapted to modulate a signal at the first wavelength ( $\lambda_x$ );
- 15    - a first receiving transponder ( $RxT_2(\lambda_x)$ ) for optically coupling to the second carrier (3) and adapted to demodulate a signal having the first wavelength ( $\lambda_x$ );
- a second receiving transponder ( $RxT_2(\lambda_y)$ ) for optically coupling to the first carrier (2) and adapted to demodulate a signal having the second wavelength ( $\lambda_y$ );
- 20    - a third receiving transponder ( $RxT_1(\lambda_y)$ ) for optically coupling to the second carrier (3) and adapted to demodulate a signal having the second wavelength ( $\lambda_y$ );
- 25    - reconfigurable optical connections (22-25; 31-38; 41-48; 131-136; 141-146; 231-236) to selectively connect:
  - the signal input ( $IN_1$ ) either to the first transmitting transponder ( $TxT_1(\lambda_x)$ ) to the third transmitting transponder ( $TxT_2(\lambda_x)$ );
  - the first receiving transponder ( $RxT_2(\lambda_x)$ ) the third transmitting transponder ( $TxT_2(\lambda_x)$ );
  - 30    • the second receiving transponder ( $RxT_2(\lambda_y)$ ) the signal output ( $OUT_1$ ); and

- the third receiving transponder ( $RxT_1(\lambda_y)$ ) either to the signal output ( $OUT_1$ ) or to the second transmitting transponder ( $TxT_1(\lambda_y)$ )

5 26) (Cancelled) Reconfigurable node according to claim 25, wherein the receiving/transmitting module (6) further includes:

- a further signal input ( $IN_2$ ) for the insertion into the node of a signal including information to be transmitted in the network;
- a further signal output ( $OUT_2$ ) for the extraction from the node of a  
10 signal including information transmitted in the network;
- a fourth transmitting transponder ( $TxT_2(\lambda_y)$ ) optically coupled to the second carrier (3) and adapted to modulate a signal at the second wavelength ( $\lambda_y$ ); and
- a fourth receiving transponder ( $RxT_1(\lambda_x)$ ) optically coupled to the first  
15 carrier (2) and adapted to demodulate a signal having the first wavelength ( $\lambda_x$ );

said reconfigurable optical connections (22-25; 31-38; 41-48; 131-136; 141-146; 231-236) selectively connecting:

- the first receiving transponder ( $RxT_2(\lambda_x)$ ) either to the third  
20 transmitting transponder ( $TxT_2(\lambda_x)$ ) or to the further signal output ( $OUT_2$ );
- the fourth receiving transponder ( $RxT_1(\lambda_x)$ ) to the further signal output ( $OUT_2$ ); and
- the further signal input ( $IN_2$ ) either to the second transmitting  
25 transponder ( $TxT_1(\lambda_y)$ ) to the fourth transmitting transponder ( $TxT_2(\lambda_x)$ ).



27) (Cancelled) Reconfigurable node according to claim 25 or 26, characterized in that it is adapted to manage a predetermined set of wavelengths within a set of transmission wavelengths ( $\lambda_1, \lambda_2, \dots, \lambda_N$ ) and in that it includes a first and a second optical add/drop multiplexer (4, 5) optically coupling the receiving/transmitting module (6) to said first and, respectively, second carrier (2, 3) to feed/extract said subset of wavelengths to/from said first and, respectively, second carrier (2, 3), and to pass-through the remaining wavelengths of the set of transmission wavelengths ( $\lambda_1, \lambda_2, \dots, \lambda_N$ ).

10 28) (Cancelled) Reconfigurable node according to claim 25 or 26, further including at least a first optical power splitter (221) for splitting signals coming from said at least a signal input ( $IN_1$ ) and at least a second optical power splitter (222-225) for splitting signals coming from a respective one of said receiving transponders (RxTs).

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29) (Cancelled) Reconfigurable node according to claim 25 or 26, wherein the reconfigurable optical connections (22-25) include 2x2 switches.

20 30) (Cancelled) Reconfigurable node according to claim 25 or 26, wherein the reconfigurable optical connections (31-38; 41-48; 131-136; 141-146; 231-236) include 1x2 and/or 2x1 switches.

25 31) (Cancelled) Reconfigurable node according to claim 25 or 26, wherein the reconfigurable optical connections (22-25; 31-38; 41-48; 131-136; 141-146; 231-236) include discrete switching components.

32) (Cancelled) Reconfigurable node according to claim 25 or 26, wherein the reconfigurable optical connections (22-25; 31-38; 41-48; 131-136; 141-146; 231-236) include an integrated switching matrix.

33) (Cancelled) Reconfigurable node according to claim 25 or 26, wherein the reconfigurable optical connections (22-25; 31-38; 41-48; 131-136; 141-146; 231-236) include optical switching components selectable in the group including:

- opto-mechanical switches;
- 5        - thermo-optical switches;
- magneto-optical switches;
- liquid crystal switches;
- semiconductor switches;
- electro-optical switches;
- 10       - micro-mechanical switches; and
- lithium niobate integrated circuit switches.

34) (Cancelled) Reconfigurable node according to claim 25 or 26, characterized in that it includes a control processing unit (16) operatively connected to said  
15 receiving transponders (RxTs) and said transmitting transponders (TxTs).

35) (Cancelled) Reconfigurable node according to claim 25 or 26, characterized in that it includes at least a further receiving/transmitting module which has substantially the same structure of said receiving/transmitting module (6) and is  
20 adapted to operate with a different pair of wavelengths with respect to said receiving/transmitting module (6).

36. (New) An apparatus, comprising:

a first ring network having a first optical carrier; and

a second ring network having a second optical carrier, wherein the first optical carrier is operable to transmit one or more signals in a first direction and the second optical carrier is operable to transmit one or more signals in a second direction that is opposite to the first direction, and wherein the first and second ring networks implement a wavelength division multiplexing protocol, the first and second ring networks including:

a pair of nodes that comprise a first and a second node, the pair being coupled along the first and second optical carriers and being operable to manage a subset of wavelengths within a set of transmission wavelengths, wherein the first and second nodes are further operable to communicate with each other and to communicate along a working path under normal operative conditions, the first and second nodes being further operable to communicate with each other along a protection path during a failure within a selected one of the first and second ring networks such that one or more optical signals are rerouted along the protection path during the failure.

37. (New) The apparatus of Claim 36, wherein the first and second ring networks are operable to propagate one or more optical signals in one or more transmission channels included therein, the one or more transmission channels being defined by a set of wavelengths having a predetermined wavelength transmission band.

38. (New) The apparatus of Claim 36, wherein the pair of nodes are operable to communicate optical data at first and second wavelengths.

39. (New) The apparatus of Claim 38, wherein the working path utilizes the first wavelength for optical data propagation on the first ring network and the second wavelength for optical data propagation on the second ring network.

40. (New) The apparatus of Claim 39, wherein the first wavelength is not used on the second ring network for optical data propagation and the second wavelength is not used on the first ring network for optical data propagation.

5 41. (New) The apparatus of Claim 39, wherein the pair of nodes are operable to communicate optical data at a pair of generic wavelengths that define a logical ring that may include the working path that utilizes the first wavelength on the first ring network and the second wavelength on the second ring network.

10 42. (New) The apparatus of Claim 38, wherein the protection path utilizes the first and second wavelengths to communicate optical data.

43. (New) The apparatus of Claim 36, wherein the first and second nodes are operable to perform add/drop/bypass operations for one or more optical signals propagating along a selected one of the first and second ring networks.  
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44. (New) The apparatus of Claim 36, wherein the first and second nodes are operable to perform an amplification operation for one or more optical signals propagating along a selected one of the first and second ring networks.  
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45. (New) The apparatus of Claim 36, wherein the first and second nodes are operable to perform a regeneration operation for one or more optical signals propagating along a selected one of the first and second ring networks.

25 46. (New) The apparatus of Claim 36, wherein the first and second ring networks define an optical transmission system that includes inner and outer ring networks that are operable to facilitate propagation of optical data in opposite directions.